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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/809,681	03/26/2004	Shoso Shingubara	925-287	7860

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EXAMINER	
BAREFORD, KATHERINE A	

ART UNIT	PAPER NUMBER
1792	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/809,681	SHINGUBARA ET AL.	
	Examiner	Art Unit	
	Katherine A. Bareford	1792	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *19 March 2008*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-17* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-17* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. The amendment of March 19, 2008 has been received and entered. With the entry of the amendment, claims 1-17 are pending for examination, including new claims 14-17.

Double Patenting

2. Applicant is advised that should claim 6 be found allowable, claim 12 will be objected to under 37 CFR 1.75 as being a substantial duplicate thereof. When two claims in an application are duplicates or else are so close in content that they both cover the same thing, despite a slight difference in wording, it is proper after allowing one claim to object to the other as being a substantial duplicate of the allowed claim. See MPEP § 706.03(k).

Applicant has provided that claim 12 depends from claim 1, so it substantially duplicates claim 6, which also depends from claim 1. If applicant intended claim 12 to depend from claim 8, the claim should be amended to clarify.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

5. Claims 1, 2, 4, 7-9 and 13-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted state of the prior art in view of Kawanoue et al (US 6229211).

The admitted state of the prior art, at pages 1-4 of the specification, teaches a known process for making embedded multilevel interconnects. For example, the process includes forming a hole portion in an insulating layer (page 2, line 25 through page 3, line 7). Then a barrier metal film of TaN is formed on the hole portion walls, by a method such as sputtering (page 3, lines 5-10). An oxide film formed on a surface of the barrier metal film is removed by etching (page 3, lines 5-15). Then, an electroless plating step of immersing the barrier metal film in a plating liquid comprising copper,

thereby forming an electroless copper plating film on the barrier metal film occurs (page 3, lines 15-18).

Claims 7, 13: Finally, an electrolytic copper plating step occurs over the electroless copper plating film (which thereby acts as the seed layer for the electrolytic plating) (page 3, lines 18-21).

The admitted state of the prior art teaches all the features of these claims except (1) the element composition ratio of N/Ta (claims 1, 2), (2) the removal step is such that the barrier metal film is left in such a manner that it entirely covers the inner wall of the hole portion (claim 4), (3) by controlling the composition and thickness of the barrier metal film, after the removal step the barrier metal film is left in such a manner that it essentially entirely covers the inner wall of the hole portion (claim 8), (4) controlling the element composition ratio to provide native oxide thickness less than 1 nm/0.5 nm (claims 14-17).

However, Kawanoue teaches barrier metal films that can be used when forming embedded multilevel interconnection, where a copper layer is applied over the barrier films. Column 1, lines 5-40, column 8, lines 5-25 and Figures 3B and 3D, for example. A barrier film is applied to a hole portion area of an insulating layer. Figures 3B and 3D, for example, and column 8, lines 5-25. The barrier film can be tantalum nitride, and can be formed by sputtering. Column 3, lines 50-65 and column 8, lines 5-25 and 50-65. The ratio of nitrogen to tantalum (N/Ta) can be 1.19, for example. Figures 3A and 3E, for example, and column 8, lines 1-30 (film 32 or film 39). Therefore, when depositing, the

composition of the barrier metal film is controlled (see column 7, lines 55-60). Kawanoue further teaches that the composition ratio of a TaN layer can be such that N/Ta is >1 (TaNx, x>1) (with x being other than 1.19, for example) as long as alternate layers of TaNy, y ≤ 1, are also used. Column 10, lines 30-45. The thickness of the applied barrier metal film is also controlled. See column 7, lines 45-55 (20 nm on the bottom and 5 nm on the side walls). When copper is applied over the barrier film, the barrier film is provided in such a manner that it entirely covers the inner wall of the hole portion. Figures 3A and 3E and column 7, lines 45-55.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the admitted state of the prior art to use a N/Ta ratio of 1.19, for example, and control the composition of the barrier metal film applied to provide this ratio, as suggested by Kawanoue with an expectation of desirable protective barrier action, because the admitted state of the prior art teaches the desire to provide TaN films by a method such as sputtering for forming barrier films for embedded multilevel interconnects, and Kawanoue teaches that TaN films provided by a method such as sputtering for forming barrier films for embedded multilevel interconnects can acceptably have a N/Ta ratio of 1.19, beneficially when used with other layers of TaN with an N/Ta ratio of ≤ 1. Furthermore, as to claims 2 and 9, it would also have been obvious to perform routine experimentation to optimize within the range of N/Ta ratios of greater than 1 to find an optimum N/Ta ratio for the specific use intended, as Kawanoue teaches that other ratios of greater than 1 used,

when used with other layers with an N/Ta ratio of ≤ 1, and In the case where the claimed ranges "overlap or lie inside ranges disclosed by the prior art" a prima facie case of obviousness exists. In re Wertheim, 541 F.2d 257, 191 USPQ 90 (CCPA 1976). Furthermore, it would also have been obvious to modify the admitted state of the prior art to perform the removal step such that the barrier metal film is left in such a manner that it entirely covers the inner wall of the hole portion when copper coating is performed as suggested by Kawanoue in order to provide a desirable copper plating, because the admitted state of the prior art provides applying a barrier film to hole walls and etching the barrier film (to remove oxide) prior to applying copper and Kawanoue teaches that it is well known when applying a barrier film to hole walls prior to applying copper, to have the barrier film covering all of the hole walls before applying the copper. Furthermore, it would also have been obvious to modify the admitted state of the prior art to control the thickness of the barrier metal film when applying as suggested by Kawanoue to provide predicatable repeatable results, because the admitted state of the prior art teaches the desire to provide TaN films by a method such as sputtering for forming barrier films for embedded multilevel interconnects, and Kawanoue teaches that TaN films provided by a method such as sputtering for forming barrier films for embedded multilevel interconnects are desirably applied to a controlled thickness such as 20 nm on the bottom and 5 nm on the side walls, and further shows that this thickness covers all the hole walls before applying the copper, and one of ordinary skill in the art would wish to apply coatings to a controlled

repeatable thickness for repeatable results. As to the claimed "by controlling the composition and the thickness of the barrier metal film, after removal of the oxide film the barrier metal film essentially entirely covers the inner wall of the hole portion, thereby preventing development of a void within the hole portion" (claim 8), the fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985). Here, the admitted state of the prior art in view of Kawanoue provides applying the barrier metal film within the composition range claimed and a thickness greater than that required by applicant for essentially entirely covering the inner wall to prevent developments of void, and therefore the claimed "after removal of the oxide film the barrier metal film essentially entirely covers the inner wall of the hole portion, thereby preventing development of a void within the hole portion" occurs. As to the claimed choosing the N/Ta ratio to control film thickness of the native oxide to be 1 nm/0.5nm or thinner (claims 14-17), the fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985). Here, the admitted state of the prior art in view of Kawanoue provides choosing and applying the barrier metal film within the ratio claimed (1.19) for claims 1 and 8, and therefore the claimed native oxide thickness of 1 nm or thinner will occur (as shown by

applicant's Figure 2 and specification at page 9). Furthermore, as to the native oxide thickness of 0.5 nm or thinner, as discussed above, the ratio range claimed in claims 2 and 9 (1.3-1.5) would also be suggested by the combination of the admitted state of the prior art in view of Kawanoue, and therefore the claimed native oxide thickness of 0.5 nm or thinner will occur (as shown by applicant's Figure 2), and thus would be another advantage which would flow naturally from following the suggestion of the prior art.

6. Claims 3 and 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted state of the prior art in view of Kawanoue as applied to claims 1, 2, 4, 7-9 and 13-17 above, and further in view of Miyamoto (US 6284649).

The admitted state of the prior art in view of Kawanoue teaches all the features of these claims except that the TaN film is formed by plasma nitriding tantalum.

However, Miyamoto teaches a method of forming a tantalum nitride barrier layer to use in semiconductor devices, where the barrier layer is applied in a connection hole and then Cu is applied over the barrier layer. Column 1, line 35 through column 2, line 10. Miyamoto teaches that one way to achieve the tantalum nitride barrier layer is to apply a tantalum layer and then performing plasma nitriding to form the tantalum nitride. Column 10, lines 1-55 and column 9, lines 1-30.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the admitted state of the prior art in view of Kawanoue to achieve the tantalum nitride barrier film by applying tantalum and plasma nitriding

as suggested by Miyamoto in order to provide a desirable barrier film, because the admitted state of the prior art in view of Kawanoue teaches forming a TaN barrier film onto which copper is to be applied, and Miyamoto teaches that a well known way of achieving such a TaN barrier layer is by applying tantalum and then plasma nitriding.

7. Claims 5-6 and 11-12 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted state of the prior art in view of Kawanoue as applied to claims 1, 2, 4, 7-9 and 13-17 above, and further in view of Wang et al "Electroless Plating of Copper on Metal-Nitride Diffusion Barriers Initiated by Displacement Plating" (Hereinafter Wang Electroless Article).

The admitted state of the prior art in view of Kawanoue teaches all the features of these claims except the acid system used for the removal of oxide (claim 5, 11) and the reducing agent for the electroless plating (claim 6, 12). The admitted state of the prior art, page 3, lines 10-15, teaches to remove the surface of the barrier film by etching.

However, Wang Electroless Article teaches a method of forming interconnects, where tantalum nitride is used as a barrier material. Page C38. The tantalum nitride is applied to the surface by a process such as sputtering. Page C38, column 2. Then the substrate with TaN is etched with HF: HNO_3:H_2O solution (hydrofluoric acid: nitric acid: and water – a diluent of hydrofluoric acid). Page C38, column 2 (the use of the water would also provide that diluted hydrofluoric acid is present). This removes the oxide from the surface. Pages C38-C39 (see paragraph bridging pages). Then electroless

copper plating is performed. Page C38, column 2. Moreover, Wang Electroless Article teaches that the reducing agent used for the electroless copper plating bath can be glyoxylic acid. Page C38, column 2.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the admitted state of the prior art in view of Kawanoue to etch treat the tantalum nitride film by immersing in a solution of hydrofluoric acid, nitric acid, and a diluent of hydrofluoric acid to remove oxide as suggested by Wang Electroless Article in order to provide a desirable barrier film, because the admitted state of the prior art in view of Kawanoue teaches forming a TaN barrier film onto which copper is to be applied and etching before copper plating, and Wang Electroless Article teaches that a well known way of achieving such etching for a TaN barrier layer before copper plating is by applying solution treating, which would suggest immersion to apply the solution, with solution of hydrofluoric acid, nitric acid and a diluent of hydrofluoric acid to remove oxide. Thus, for example, a mixture of hydrofluoric acid and nitric acid would be used. It would further have been obvious to modify the admitted state of the prior art in view of Kawanoue to use glyoxylic acid as the reducing agent for the copper electroless plating bath as suggested by Wang Electroless Article in order to provide a desirable copper plating, because the admitted state of the prior art in view of Kawanoue teaches forming a TaN barrier film onto which copper is applied by electroless plating, and Wang Electroless Article teaches that a well known

way of achieving such electroless plating on a TaN barrier film is by using glyoxylic acid as the reducing agent for the electroless plating bath.

Response to Arguments

8. Applicant's arguments filed March 19, 2008 have been fully considered but they are not persuasive.

Applicant argues that they have now changed the N/Ta ratio to 1.0-1.5 (claims 1, 8) and 1.3-1.5 (claims 2, 9), which allows for a native oxide thickness of 1 nm or thinner, and 0.5 nm or thinner, respectively. Applicant argues that Kawanoue does not address the importance of the claimed ratio ranges and fails to recognize that the thickness of a native oxide controlled in the manner accomplished by applicant is also an important factor and Kawanoue does not teach or suggest such a factor.

The Examiner has reviewed these arguments, however, the rejection is maintained. First as to the N/Ta ratio of 1.0-1.5, the Examiner notes that as discussed in the rejection above, Kawanoue provides examples that use an N/Ta ratio of 1.19, within the claimed range, thus providing the suggestion to use such an N/Ta ratio. Furthermore, as discussed above, since the specific N/Ta ratio within the claimed range that provides the native oxide layer of less than 1 nm is provided, as to the claimed choosing the N/Ta ratio to control film thickness of the native oxide to be 1 nm or thinner (claims 14-15), the fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis

for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985). As to the N/Ta ratio of 1.3-1.5 (claims 2, 9), Kawanoue further provides that an N/Ta ratio of greater than 1 can be used, when used with other layers with an N/Ta ratio of ≤ 1 (see column 10, lines 30-45) and it would be obvious to perform routine experimentation to optimize within this claimed range because In the case where the claimed ranges "overlap or lie inside ranges disclosed by the prior art" a prima facie case of obviousness exists. In re Wertheim, 541 F.2d 257, 191 USPQ 90 (CCPA 1976). Furthermore, as to the native oxide thickness of 0.5 nm or thinner (claims 16-17), as discussed above, the ratio range claimed in claims 2 and 9 (1.3-1.5) would also be suggested by the combination of the admitted state of the prior art in view of Kawanoue, and therefore the claimed native oxide thickness of 0.5 nm or thinner will occur (as shown by applicant's Figure 2), and thus would be another advantage which would flow naturally from following the suggestion of the prior art.

Conclusion

9. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the

shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Katherine A. Bareford whose telephone number is (571) 272-1413. The examiner can normally be reached on M-F(6:00-3:30) First Friday Off.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Timothy H. Meeks can be reached on (571) 272-1423. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Katherine A. Bareford/
Primary Examiner, Art Unit 1792